A POPULAR

GUIDE TO THE ELECTROTYPE;

CONTAINING

CONCISE & SIMPLE INSTRUCTIONS

IN

THE VARIOUS PROCESSES OF ELECTRO-METALLURGY,

WITH THE

ART OF MOULDING

IN PLASTER, WAX, FUSIBLE METAL,

ETC., ETC.

BY J. H. CROUCHER,

EDITOR OF THE "PHOTOGRAPHIC MANUALS."

PART I.

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A POPULAR GUIDE

TO

THE ELECTROTYPE.

Perhaps no branch of scientific manipulation has attracted so much of public attention as that of the Electrotype. From its first discovery, it has been a very favorite process with amateurs. The trifling cost of the apparatus, the facility with which the operation can be commenced and carried on, and the almost certainty of a fair measure of success, with ordinary care and attention, have all conduced to make it highly popular, and well justify the introduction of the subject into our series of Scientific Manuals. We shall endeavour to follow out the system we have adopted in former numbers, by studying to render all our instructions plain and succinct, divested as far as possible of all technical formality, but sufficiently comprehensive and minute for every purpose of utility.

It does not come within the scope of our design to give any lengthened account of the philosophical principles involved in the class of operations known under the general term of Electro-Metallurgy, or Electrotype. The agent which produces such striking and beautiful effects may be studied by those who desire a philosophical acquaintance with the subject, by the aid of the many valuable works which treat on Electricity. We are indebted to two Italians, Galvani and Volta, for the discovery and early developement of this branch of the science. Its powers and properties were further elucidated by Sir H. Davy; while to the labours of Wollaston, Ruolz, Daniels, Leeson, Smee, De la Rue, Groves, and other distinguished men, we are indebted for instruments which have wonderfully enlarged the sphere of its applications.

Voltaic Electricity, or Galvanism, so called after the two Italian

Professors just named, is developed by chemical action. If a plate of zinc and a plate of copper, united together by a piece of copper wire, be plunged in water slightly acidulated by sulphuric acid, the water is decomposed; one element, oxygen, uniting with the zinc, forming oxide of zinc,—the other, hydrogen, escaping. While this action is proceeding, a current of electricity is passing from the zinc through the fluid to the copper, and back again by the wire which unites the two. This and similar arrangements constitute what is called a battery. The zinc is termed the positive metal, and the copper the negative. Zinc, having a great affinity for oxygen, is almost invariably used as the positive metal, but the copper may be replaced by various other metals; platinum, or platinized silver, is more commonly employed. All that is necessary to form a good battery, is to have a metal possessing a strong affinity for oxygen, as zinc; another which has but a slight attraction for it, as copper or platinum; and a fluid, which, while it forms a good conductor can be easily decomposed, as water, to which a small quantity, say one-tenth of sulphuric acid, has been added.

Two or three of the more popular forms of battery we shall here describe; reserving a more particular account of these valuable instruments, and their adaptations, until the subject of Voltaic Electricity comes more immediately under consideration.

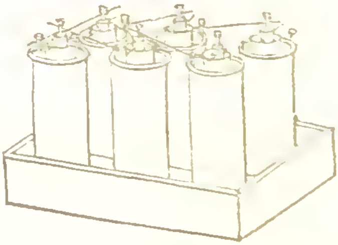


Fig. 1.

The Constant Battery of the late Professor Daniel consists of a copper vessel or a jar coated with copper, and of a rod of amalgamated zinc enclosed in a porous cell. The inner cell is filled with dilute sulphuric acid, the outer with a saturated solution of copper. Connection is made by means of binding screws attached to the metal. It may be remarked upon this battery, that the term 'constant' is applied with reference to its power of developing the same amount of electricity while it is in action, and not with respect to the length of time it will remain in action. It is the same property as that which constitutes a good chronometer; its going at a constantly even rate until the motive power being exhausted it is compelled to stop. This battery has the advantage of giving forth no fumes.

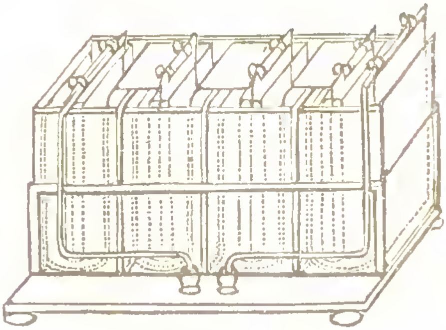


Fig. 2.

GROVES'S BATTERY.—This battery has for its elements zinc and platinum. A thin sheet of this last metal immersed in strong nitric acid contained in a porous cell is surrounded on either side with plates of zinc. The zinc and porous cell are both placed in a vessel containing a very dilute solution of sulphuric acid and water. This arrangement forms a most powerful battery, but from the noxious fumes of nitrous acid gas given off, it can only be used in the open air, or in a room very well ventilated. It is usually constructed in a series of several pair in a wooden or porcelain trough.

The Battery of M. BUNSEN differs but slightly from that of Mr. Groves; the platinum is replaced by charcoal. It is usually constructed as follows:—A cylinder of charcoal, A, the upper part of which is mounted with a band of copper, B, is fitted into a glass bottle, and a rod of amalgamated zinc, C, in a porous cell introduced into the charcoal cylinder. To charge the battery, the porous cell is withdrawn, and a solution of equal quantities of nitric acid and water poured into the bottle, until it is about half full; the cell having been filled with very dilute sulphuric acid, one part acid to 40 or 50 parts water, is returned to its place, and connection is made by means of ribbons of copper soldered to the zinc and the collar surrounding the charcoal. This battery has the advantages of moderate price, and of very considerable energy; but like that of Groves' it is objectionable on account of the vapour given off, and from the trouble

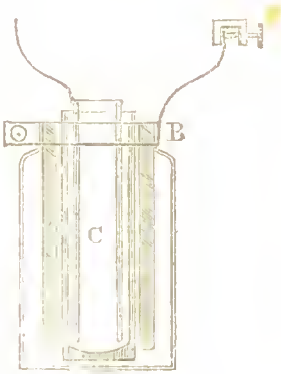


Fig. 3.

and expense attending the use of porous cells. This Battery is also usually made in series, as in fig. 4.

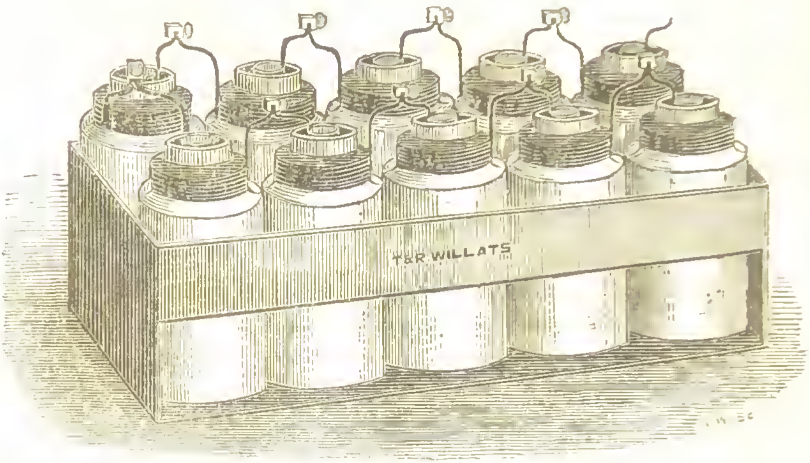


Fig. 4

In DR. LEESON'S BATTERY the copper is placed in a porous cell charged with a solution of the bi-chromate of potash, one part of the bi-chromate to ten parts water, the sides and bottom of the outer trough are formed by the zincs, and this trough is filled with the usual acid solution. Connection is made by bending over the top of the copper, and attaching it to one of the zincs by a binding screw.

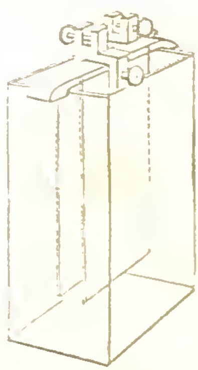


Fig. 5.

SMEE'S BATTERY is, however, the one most commonly preferred for Electrotyping purposes. It is remarkable for the ease and celerity with which it may be put in action, for the abolition of the porous diaphragm, for the entire absence of noxious fumes, and for its economy when employed in depositing metals. A thin plate of silver, which is covered with platinum in the form of a fine black powder, is fixed into a bar of wood, on each side of which is a plate of amalgamated zinc, the zincs being held firmly against the wood, or removed, at pleasure, by means of a binding screw. This arrangement is immersed in a mixture of one part sulphuric acid in about ten parts water. The instant connection is made between the zinc and the silver an energetic action commences. It is necessary to be very cautious that not

even a drop of the solution of sulphate of copper be allowed to fall into the acid mixture as a deposition of copper on the platinized silver would inevitably follow. This battery is constructed of various forms, according to the purpose to which it is to be applied. A convenient form is figured below.

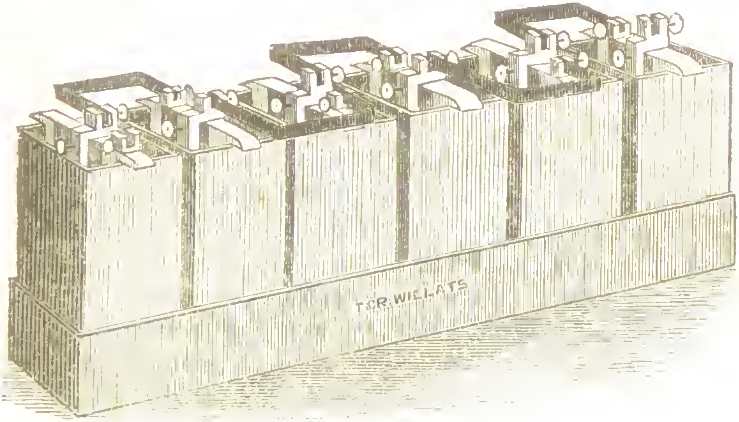


Fig. 6.

PROFESSOR JACOBI, of St. Petersburgh, has recently introduced a very novel form of battery, invented by Prince Bagration. It is very simple, and cheap in its construction, and is said to be very constant in its action. Any vessel such as a flower pot impenetrable to water, is filled with earth saturated with a concentrated solution of sal-ammoniac in water. A plate of copper and a plate of zinc, as large as possible, are buried in this earth, at a moderate distance the one from the other. Before placing the copper in the earth, it is desirable to plunge it for some minutes in a solution of sal-ammoniac, and to let it dry until a decided oxidation appears upon its surface. By moistening the earth occasionally, and renewing the zinc when necessary, this battery may be continued in constant action for a great length of time

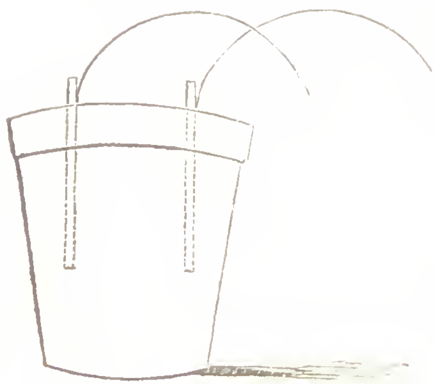


Fig. 7.

A single pair of any of these elements is sufficient for many purposes, but when considerable power is required a number of pairs are united and form a compound battery. The QUANTITY of Electricity produced, depends upon the size of the negative plate and the nature of the solution with which the battery is charged; its INTENSITY, or power of overcoming resistance, upon the number of pairs employed.

The VOLTAIC BATTERY has a variety of properties which can be only glanced at here.

Its calorific power is manifested by the readiness with which the most intractable metals are fused. When charcoal points are attached to the wires of a compound battery, and brought nearly but not quite in contact, a most brilliant light is evolved, and with a large series of batteries an arc of flame of the most vivid character is produced. The needle is deflected, and magnetism induced in a bar of soft iron by the same agency; a Leyden jar may be charged, and a shock given as by frictional electricity, but this effect is shewn with more advantage by the use of a coil of iron wire, in which a current of electricity is produced by induction.

But the property which has the most important bearing upon our present subject, is that by which compound bodies are decomposed. This power called the Electrolytic power, is exemplified in the decomposition of water already referred to.

Pure water, being a bad conductor of electricity, is decomposed with difficulty, but the addition of a few drops of acid will cause it to yield up its elements with great readiness. This power is very simply and beautifully exemplified by electrolysing an infusion of red cabbage in a glass tube bent into the form of the letter V. Corks are fitted to the ends of the tube through which two pieces of platinum wire pass into solution. On connecting the wires of a battery with the platinum the liquid nearest the positive pole will become green, shewing the action of an alkali; and that nearest the negative red from the presence of an acid. Dr. Faraday has given the name of *electrode* to the substance by which the electricity enters or leaves a body suffering decomposition. The surface at which the current enters a decomposing body is further called the *anode*, and that at which its leaves it the *cathode*. When metallic solutions are submitted to the action of the voltaic current, the metal will generally be released. If water contain sulphate of copper, for example, the copper will be deposited on the

negative wire, while the released acid will attack the positive wire and dissolve it. It is to the observation of this fact that we owe the interesting processes of the ELECTROTYPE. The laws which govern the deposition of metals are few and simple, and will be referred to as we proceed.

The art of electrotyping is usually dated from the invention of the constant battery by Professor Daniel, who however was not the first to remark its application to the reproduction of works of art. So early as 1803, Brugnatelli, a chemist of Pavia, had noticed the reduction of metals by the galvanic current, and M. de la Rive remarked the exactness with which every line and mark on the outer cell of Daniel's Battery was reproduced on the copper deposited, but without applying his observation to practical purposes. In October 1838, however, Professor Jacobi announced his application of the reduction of copper to the purposes of art; and in 1839, Mr. Spencer of Liverpool, published the methods by which he had executed medals in copper, with the aid of the voltaic battery. To Mr. Murray we are indebted for one of the most important improvements in the art of Electrotype, the use of plumbago, or blacklead, as a means by which non-conducting substances can be covered with a metallic coating, and rendered conductable. The Electro-gilding and silvering, now so common, was we believe first proposed by Mr. de la Rive; but to the labours of Messrs. Boettger, Elsner, and particularly of Messrs. Smee, Leeson, Elkington, and Ruolz, we owe its present perfection and extension. The application of Galvanism to engraving, to the reproduction of engraved plates, Daguerreotype proofs, etc. is recent and well known. Still more recent and valuable is the discovery of a most economical mode of separating copper from its ores by the action of the galvanic current.

These notices of the scientific principles upon which the Electrotype process is founded, and of its history and application, have been necessarily very brief and imperfect. The remainder of the present number will be devoted to some practical directions for conducting the process as far as the reduction of copper is concerned, for preparing the various substances which are to receive the deposit, and for mounting and preserving the works of art so obtained. We shall reserve to a second part the consideration of the arrangements required to effect the deposition of the other metals, and of some other applications of Electro-metallurgy.

ELECTROTYPE MANIPULATION.

The deposition of copper, by means of the Electrotype, has been largely employed in the useful arts. Several patents have been taken out for the more important applications of the discovery, with some of which the public are familiar. To these we shall allude briefly as we proceed; but our present object being to facilitate the operations of the amateur, desirous of practising an elegant and pleasing art, we shall direct the reader's attention chiefly to such manipulations, as a few simple directions, and a small inexpensive apparatus, will enable him to perform. Thus much accomplished, he will find little or no difficulty in understanding the more scientific details given in larger works, or in undertaking operations on a greater scale. Nor is the field on which he will be enabled at once to enter a limited one—it includes the obtaining facsimiles of coins, medals, and seals—the copying the beautiful but fragile casts in plaster, many of which are gems of art—the modelling of fruits, flowers, and leaves—the reproduction of the exquisitely perfect pictures produced by the Daguerreotype, with a variety of other works of a similar character.

MEDALS AND COINS.

Many of these veritable documents in history are of great rarity and consequent value, the boast and pride of our numismatic cabinets. The young collector seldom entertains the remotest idea of possessing such valuable treasures, but for the completing of various series, the more common specimens of which may be within his reach, he is naturally anxious to obtain copies of the originals; and these he can procure with great ease and perfection, by the Electrotype. Memorials so highly prized ought never to be submitted directly to a process, which in inexperienced or careless hands, would prove their destruction; and hence it is necessary to learn the various ways in which metal, plaister, or other moulds may be made from a coin or medal, so as afterwards to assist in re-producing a fac-simile. If, however, the object, being of trifling value, can be safely placed in a metallic solution, a copper mould, the exact counterpart of the

original may be obtained by the agency of the galvanic current. If both sides of the object are to be copied, it will only be necessary to pass a fine copper wire round the rim, and to grease the remaining part of the rim to prevent the deposit entirely embedding the coin; if only one side is wanted, the opposite side must be coated with grease, wax, or a non-conducting substance. The wire will serve to connect it with the zinc of the battery.

Another method of obtaining metallic moulds is by the use of a fusible metal, of which there are many varieties. The composition of the more useful of these is as follows:—The ordinary fusible metal of which spoons that melt in boiling water are made, is composed of eight parts bismuth, three parts tin, and five parts lead.

The alloy of which the much admired French medals is composed contain a small quantity of antimony. The proportions used are as follows:—bismuth eight parts, tin four parts, lead five parts, antimony one part.

The metals are to be put together into a clean iron ladle, and placed over a clear fire. When melted, the fluid metal is poured upon a stone slab in drops. It is necessary to repeat this process three or four times, to secure the perfect mixture of the alloy. The mould is made either by the hand or with a press.

In making moulds by the hand the medal to be copied is fixed to the end of a round block of wood, either by cement or by scooping out a cavity of the size necessary to secure it firmly. The melted alloy is poured upon a sheet of cardboard or cartridge paper, which should be fixed in a box, with sides three or four inches high, sloping inwards, to prevent the metal from being scattered. The metal must be stirred together with cards until it looks pasty and is about to crystallize, when the block of wood to which the medal is attached should be taken in the right hand and firmly but gently struck upon the crystallizing metal. This operation must be exactly timed, or the mould will be imperfect. Two persons, one to stir the metal and the other to strike the impression, can manage it with more precision and certainty than one. If the surface of the metal becomes clouded, the dross must be removed by passing a card over it. For this method we are indebted to Mr. Charles V. Walker, the eminent electrician. A very simple press may be constructed for performing the latter part of the process. An upright foot is fixed in a solid stand, from which project two arms, with a socket in each through which a square rod can pass. A spring raises this

rod when not in use, and to the other end is attached the medal to be copied. In the solid stand, and directly under the rod, is fixed a small metal box about the size of the intended medal. The melted alloy being poured into this box, and allowed to attain to the proper degree of coolness, the impression is then made by forcing down upon it with both hands the medal attached to the square rod. The medal may be fixed to the rod by mastic, or let into the wood as before directed. Very perfect impressions of medals or coins may be sometimes obtained, by placing the object on sheet lead, made very clean and bright, and giving it a heavy blow with the hand: or it may be passed through a printing press; by this kind of pressure, however, it is liable to distortion.

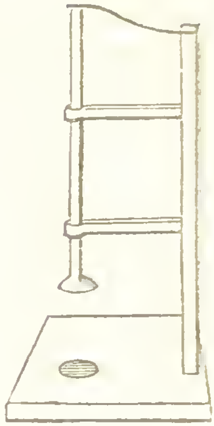


Fig. 8.

When neither of these methods can be resorted to, a mould may be taken in plaister, wax, or some similar material. The art of moulding in these substances is not difficult, but they each require a peculiarity in manipulation, which it will be our object to explain in as simple a manner as possible. The objects to be moulded must be prepared by very lightly oiling the surface with a piece of cotton and a little sweet oil. They should also have a piece of stiff paper wound tightly round them, the ends of which may be fastened with paste wafers, a piece of thread, or a cleft stick.

Plaster.

For this purpose the fine plaster sold in bags by the Italian figure makers must be procured. It should be freshly burnt, or if not, should be placed in a saucepan over a fire until it boils, or heaves up from the expulsion of the gas.

Attention is required in mixing the plaster; if too wet it will not set, and if too dry it will set before it can be used. Some water having been poured into a bason, a sufficient quantity of the plaster should be shaken in, all the surplus water poured off, and the remaining mixture thoroughly well stirred with a wooden spoon, to prevent its being lumpy or retaining air bubbles. The last operation must be done

quickly, and a little of the plaster being put into each mould, is to be hastily rubbed into all the finer parts of the work with a stiffish brush or camel's-hair pencil; then, before this has time to set, let the moulds be filled with plaster to the depth required. By tapping the bottom of the mould two or three times on a table gently, the surface will be level and free from bubbles. The plaster will generally set in about five minutes; it may be hastened by using warm water to mix the plaster. The casts obtained in this or similar ways may be used as moulds from which to obtain electrotypes. In this case,—indeed, whenever plaster is used as a mould,—it must be rendered non-absorbent. This is accomplished in many ways. The mould may be placed, face upwards, in a flat dish containing some wax, stearine, or tallow in a melted state. The dish being set by the side of the fire, the wax, &c. will gradually rise through the pores of the plaster and at length appear on the face. When every part of it is saturated, it must be withdrawn and gradually cooled. In a few hours it will be fit for use.

Several receipts for rendering plaster impermeable will be found in the Appendix. Plaster may be hardened by filling it with a solution of gum arabic or strong size. The medallions and casts sold in the shops are taken from sulphur moulds, a substance excellently adapted for moulding, but one which cannot be used for electrotyping purposes. We shall reserve the description of this and many other processes used in moulding, for a little work on the subject now in preparation.

Wax, Stearine, &c.

Common white wax or stearine, both of which are used in the manufacturing of candles, are very useful in moulding. As white wax alone is expensive and apt to crack, a portion, say one-third beeswax, or a little stearine may be added to it, and a small bit of white lead about the size of a pea to a quarter of a pound of the material. Mr Walker has recommended a compound of 8 oz. spermaceti to $1\frac{3}{4}$ oz of wax and mutton suet. The addition of a little flake white to wax produces a moulding composition of a very superior order. Black lead is sometimes used in place of the white lead or flake white. The medal to be copied is prepared as directed under the head of plaster. The wax or composition material is to be heated over a slow fire in a pipkin or pitcher, keeping it well stirred; when thoroughly melted it

should be set on one side until it begins to solidify round the edge of the vessel; when the remaining portion is just warm enough to melt this solid rim, it is ready for pouring into the moulds. The medal is held in the hand in a sloping direction, and the wax being poured into the lower part, is allowed to flow over it gradually, to prevent bubbles of air, and the mould is then filled up to the height required. The medal should be slightly warmed, and if it is large the wax may be used at a temperature rather more elevated. The wax must be left till thoroughly solid, and will usually take several hours to harden properly. It should separate from the object with great ease, but in case of adherence the separation may be assisted by very gently warming the back. In separating such moulds take care to pull them gently and at right angles from the surface of the medal.

A mixture of equal parts of beeswax and rosin is used by the Italians, and sometimes a little turpentine, with an increased quantity of rosin, is added. This composition after melting should be allowed to remain until about the thickness of treacle, and be used in that state. It is certainly not so easy as it would at first sight appear to form moulds in wax or a similar material, but a little patient experiment will enable the young practitioner to overcome all difficulties.

Sealing Wax

May occasionally be used for taking impressions of coins and medals which are very sharp and delicate. The very best should be procured. By holding a card over a spirit lamp, and previously heating the wax a considerable quantity will quickly be obtained; it must be stirred round until all the air-bubbles are dispersed, when the coin may be pressed down tightly upon it.

Some other materials are occasionally used in copying medals, but those given above are the most common and effective.

PLASTER CASTS AND MEDALLIONS.

Some of the most beautiful treasures of art are to be procured at a trifling expense in this material, and can be transferred to copper with great accuracy and perfection. The first thing to be attended to in moulding these objects is the rendering them impermeable; which may be effected in the way already described in page 23. Another

method is to keep the surface of the mould covered with boiled linseed oil, adding more as it is absorbed until it is saturated to a sufficient depth. The following is a simple method. Stand the cast, face upwards, in *boiling* water, reaching to about two-thirds of its depth: in a few moments the water will have penetrated completely through it. It is now to be surrounded with a rim of card as directed for medals, and the composition immediately poured on. For all objects in low relief, wax, or a similar material may be used. The wax should be allowed to cool slowly, and should only be removed when it will separate easily. Should any little pieces of the plaster come away with the wax, it may be removed by touching the spots of plaster with sulphuric acid, and leaving the mould exposed to the air; after some time the plaster will be disintegrated, and may be removed by the application of a camel's hair brush and cold water, without injury to the mould. Objects in high relief, and which are much undercut, cannot be moulded in this manner. A flexible material such as glue (see Appendix) must be used for this purpose, and a wax mould taken from it, on which the copper can be deposited. Perhaps the best plan in such cases is to prepare the cast for electrotyping, by covering the surface with blacklead, to render it conductible, which operation is explained further on, to coat it with a deposit of copper, and then to dissolve out the plaster by a strong solution of sulphuric acid. From this copper mould an electrotype copy may be obtained, though with some difficulty, and when sufficiently thick may be removed from by ripping off the mould.

Busts, or other large works in plaster, are either moulded in pieces, and the pieces afterwards joined together, or are simply covered with a thin coating of copper. They are prepared in the same way as other plasters; and under the head of Battery Apparatus will be found some necessary directions for managing the deposit.

SEALS.

Sealing Wax Impressions require only to be rendered conductible with black lead, and are ready for the electrotyping process. A thin coat of copper will be sufficient, but it must be backed up, as it is termed, an operation which is performed by warming it,

rubbing the back over with a little stearine, adding some solder, and then pouring in melted lead. They are afterwards mounted on handles.

FLOWERS, FRUIT, LEAVES, &c.

These and various other natural productions may be lightly covered with copper, and when gilt, silvered, or bronzed, form very beautiful ornaments; the mode of rendering them conductible will be presently noticed. All vegetable and animal substances, on which the metallic solution will not act may be treated in this way. Mr. Deeble, of Islington, has pointed out the following method of modelling leaves, flowers, etc. The flower, or leaf, being properly developed, is detached from the plant, and laid upon fine sand, moistened in the natural position, and so that all the parts which are to be moulded are above, and that the back touches the sand in every part. Then with a fine pencil the surface is covered with a thin coating of white wax and bergundy pitch melted together. The flower is immediately removed and dipped in cold water, which, hardening the wax, allows the flower to be removed without altering its form. These reliefs are of great perfection, and may be used, when prepared as moulds, from which to electrotype.

Net, Lace, etc. may be covered with copper, and presents a very pretty appearance, when gilt or silvered, forming a kind of wire gauze, useful for various fancy articles. It is prepared by soaking it in melted wax until saturated; if too much wax adheres, it can be removed by laying out the net between two pieces of blotting paper which, when warmed by holding it near a fire, will absorb all the surplus wax. They are rendered conductible by black-leading as directed further on.

Bottles, Retorts, and other Chemical Glass or Earthenware, may also receive a copper coating. The part to be operated on must be first varnished with turpentine or Canada balsam, and then blackleaded or covered with metal by the use of bronze or gold paint. A very elegant method is by exposing the glass to the action of fluohydric acid, which will just roughen the surface sufficiently to allow the blacklead to adhere very closely.

Baskets may be coated with blacklead, gold-paint, &c. and when covered with chrystalline copper make very pretty ornaments.

The objects to which reference has been made are those which most readily present themselves to the mind of the electrotypist as suitable for his purpose, and the principles thus laid down may be readily applied in the preparation of such things as have not been enumerated. We proceed to call the reader's attention more directly to the methods adopted.

TO RENDER NON-CONDUCTING SUBSTANCES CONDUCTIBLE.

Moulds in plaster, wax, stearine, or other non-conducting substances, are made available for electro-metallurgic purposes by supplying them with a thin coating of metal, or by covering them with carbon in fine powder.

There are a variety of methods of accomplishing the former object, one is the use of bronzing powders, receipts for which will be found in the Appendix, and which may be rubbed over the surface of the object with a soft plate brush, until an even coating is produced. Leaf gold is often employed for this purpose. A preparation recently introduced under the name of gold-paint may be occasionally used with advantage.

We are indebted to Mr. Spencer for an excellent method of covering the most delicate objects with a metallic coating. A small piece of phosphorus is put into a phial containing alcohol or ether. The phial is then placed in hot water for a few moments, and by repeating the process, a small portion of the phosphorus becomes dissolved. The object to be copied is dipped into a very weak solution of nitrate of silver, chloride of gold, or platinum,—or a little of the solution is spread over with a soft camel's hair pencil,—and is fixed to the upper part of a bell glass. A few drops of the preparation of phosphorus are poured into a watch glass, and gently warmed by a sand bath. When the vapour begins to be disengaged, the glass is placed over it, and in a very short time the metal will be reduced on the surface of the object. A little gum may be added to the metallic solution, when the surface to which it is to be applied is greasy or resinous. Salts of lead, or mercury in solution, may be employed in the same way. The preparation of phosphorus may be replaced by hydrogen gas passed into the glass containing the object, or by plunging the latter into a weak solution of sulphuret of potash :—a

solution of phosphorus in bi-sulphuret of carbon has been recommended, in which the object is to be dipped, and then after a few moments immersed in the nitrate of silver solution; but this preparation is so dangerous, from its extreme inflammability, as to require a very considerable degree of caution in its use.

Seals and medals may be copied in the following manner. Melt a little sealing-wax on a piece of card, and lay a piece of gold leaf on the top, then apply the seal or medal, pressing firmly till the wax is cold.

But by far the most valuable substance for giving a conducting surface to bodies is black lead. Mr. Murray was the first to recommend its use, and thereby conferred a signal benefit on the Electrotypist. It is applied very readily in the state of fine powder, by brushing it over the object with a soft plate brush; a very thin film will generally adhere, and completely cover the surface without injuring the sharpness of the mould. Care must be taken that the whole surface is perfectly and evenly covered, and that on the other hand the finer portions of the work are not choked up. If the black lead will not adhere, as is sometimes the case with sealing-wax impressions, the surface may be just touched with spirit of wine, which will slightly roughen it, but the spirit must be used with caution or the sharpness of the copy will be affected. Lace, net, etc. having been first saturated with wax in a melted state, must have the black lead brushed carefully *all* over it.

CONNECTING WIRES.

The moulds having been prepared, as above directed, must now be attached to pieces of copper wire or ribbon, by which they may be connected with the apparatus employed to deposit the metal. When cliche or other metallic moulds are employed, the wire or ribbon is usually soldered on to the back, and all those parts which are not intended to be covered with copper must be protected with a varnish prepared by dissolving a little shellac in spirits of wine. When the moulds are of wax, or of some similar composition, the end of the ribbon or wire may be warmed, and then inserted into the back of the mould. For large moulds a smaller wire should be passed round the

edge, to which the larger one may be attached. When the object is large, or has considerable depressions, as in a bust, guiding wires are used. These are pieces of fine wire which, being connected with the large conducting wire, are made to touch the surface at various points, so that the deposit may spread more rapidly and evenly. Baskets require a thin wire to be passed round them in various directions, touching the surface at short intervals. Leaves, flowers, fruit, etc. may have a pin passed through the stalk, to which the larger wire is tied. The hole which remains after the pin is withdrawn, has the advantage of allowing the juices of the plant to evaporate, and assists the preservation of the object. Lace, when prepared as has been already directed, will be quite stiff, and may be enclosed between two frames of copper ribbon, made to the size, and held together by copper thread tied round them at short distances. The frames are easily constructed by cutting the ribbon into proper lengths, and soldering the ends together ; a piece may be soldered to the middle of one of the frames, by which to connect it with the battery.

Binding screws are used to connect the conducting wires with the object, but when this is inconvenient, it is necessary to have recourse to soldering. This operation, common as it is, presents some difficulties, as copper, and some other metals, will not unite unless they are perfectly free from all trace of oxide. By the use of chloride of zinc, this operation may be accomplished with facility and certainty. It is prepared as follows :—Small pieces of zinc are added to hydrochloric acid until the acid is saturated. It is then evaporated by a gentle heat until it is of the consistence of oil. It should be tested with litmus paper, to be sure that there is no acid reaction. When required for use, it is only necessary to clean the surfaces to be united with a file or piece of sand paper, and having slightly moistened them with the liquid, immediately to tin them with a little solder and a soldering iron ; then having put them exactly together, finish the soldering either with an iron or by the flame of the spirit lamp.

A still more simple method is recommended by M. Lockey. Having cleaned the pieces to be soldered as before directed, warm them over the flame of a spirit lamp, and rub them over with a bit of stearine. Then apply a very small portion of solder to the point heated, which will spread and unite with the copper. Having placed the pieces in contact, hold them with a hand-vice over the flame, and when sufficiently heated, allow them to cool before removing the vice.

These two methods, especially the first, will answer for all metals which are capable of being soldered with the tin solder.

Having given the amateur the necessary instructions for preparing the objects which he wishes to cover with a coating of copper, we proceed now to describe

THE ELECTRO-METALLURGIC APPARATUS.

The apparatus used in Electrotype Manipulation is neither intricate nor expensive. It is generally comprised under the heads of Single Cell, and Battery Apparatus. The single cell apparatus, to which we shall first allude, consists of a single pair, the positive element of which is a plate of amalgamated zinc. This is placed in a porous cell, filled with an acid or saline solution; and the object to be copied, which forms the negative element in a solution of the metal to be deposited. The galvanic current is thus transmitted directly from the zinc to the object, without any intermediate agency. The circuit is established by means of a piece of copper wire, which unites the two elements. The principle of Daniel's Battery is carried out in this apparatus.

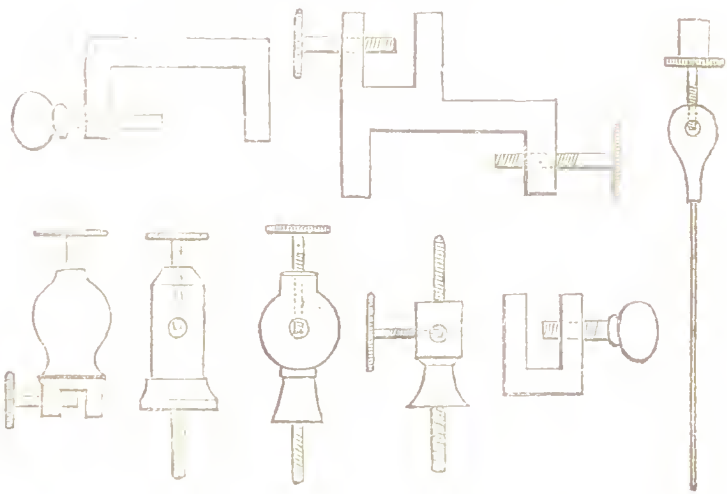
Troughs of baked wood, rendered water-tight by a cement, the receipt for which will be found in the Appendix, of salt glazed stoneware, or of hard glazed porcelain, are used to contain the solution of copper; and are generally furnished with pierced shelves, upon which crystals of the metallic salt may be laid to keep up the saturation of the solution, a point of the greatest importance.

Diaphragms are intended to prevent the mixing of two solutions in the same trough, and are made of various substances. Brown paper and animal membrane may be used for the purpose, but they are easily destroyed, and never keep the solutions entirely separated. Plaster of Paris diaphragms answer the purpose pretty well, and may always be employed where better or more suitable ones cannot be obtained. They may be made of the common plaster used by builders, and by any one who has the slightest knowledge of casting in this material, directions for which we have already given. But the most useful diaphragms are made of a porous clay, such as is employed for manufacturing wine and butter coolers. It should be well baked, and thoroughly porous throughout every part. These may be obtained, of various shapes and sizes, of the Philosophical Instrument Makers. The porous cell con-

tains an acid or saline solution, in which the zinc is immersed, and is itself placed in the trough containing the copper solution.

Metallic diaphragms have been strongly recommended by recent writers, as allowing a ready passage to the galvanic current yet opposing the mixture of the fluids, and these are worthy a trial. Copper may be used in liquids which do not attack it, but in the opposite case it must be gilded or platinized, or a diaphragm of cast iron adopted. Care must be taken that these diaphragms do not come in contact with either of the elements. All diaphragms should be soaked in water before and after using. Binding screws are necessary to connect the object to be copied with the zinc, and thus to form a galvanic circuit. They are of various descriptions as figured below.

Figs. 9, 10,



Figs. 11, 12, 13, 14, 15, 16.

The zinc of the single cell apparatus is amalgamated to prevent the acid in which it is immersed acting chemically upon and rapidly dissolving it. This local action is attributed to the foreign matters contained in the zinc plate, which form among themselves numerous small batteries. To amalgamate the zinc, dip it in dilute sulphuric acid, and then with a brush rub mercury well over it, until the whole is covered or mercury and acid may be placed together in a plate, and then rubbed over with a brush. The more mercury the plate will take up, the longer it will last. Mr. Kemp first pointed out this method, by which the properties of pure zinc are given to the ordinary metal.

But the use of this metal is not compulsory, a sheet of cast iron will answer the purpose well; and as it is very much cheaper than zinc, is a desirable substitute, when a large extent of surface is required. As however the iron cannot be amalgamated, it is necessary to use a saline solution to prevent the effects of local action; and some sulphate, such as sulphate of soda or magnesia, is perhaps the most convenient.

The Single Cell apparatus is constructed of various patterns, according to the fancy of the maker, or the particular purpose to which it is to be applied. The commonest is an earthenware jar, figured in the margin, partly covered by a shelf perforated with small holes, for the crystals of copper, and with a larger aperture to admit of the introduction of a round porous clay cell. In this cell a rod of zinc is placed; and the wire, to which is attached the object to be copied is connected with it by a binding screw. By putting the porous cell in the centre of the jar, and connecting the zinc with a rim of copper, fitted to the edge of the jar, the apparatus is improved, as several objects can be hung upon the copper rim, and receive the deposition at the same time. Another and very desirable arrangement consists of a hard glazed porcelain trough, fig. 18 about 5 or 7 inches square, with shelves for the crystals of copper: the plate of zinc fits into a flat porous cell, and is connected by a binding screw and slips of copper with two brass bars, to which may be attached the objects to be copied.

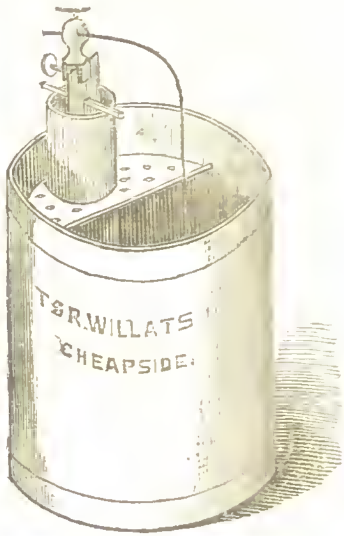


Fig. 17.

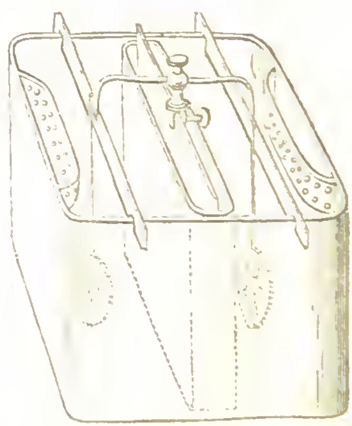


Fig. 18.

In another form of apparatus, fig. 19, a square wooden trough,

coated with cement, is divided horizontally by a moveable shelf of mahogany. A glass cylinder, one end of which is covered over with a bladder, is placed on the shelf, and occupies the place of the porous tube used in other apparatus. The glass vessel is occupied by the acidulated water and the zinc, and the outer trough with the sulphate of copper solution, in which the cast is placed in an horizontal position. Connection is made by wires and screws, which are passed into two holes in a piece of brass at the side of the trough. This form offers peculiar facilities for changing the acids, zincs, etc.

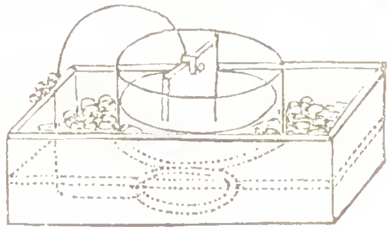


Fig. 19.

The apparatus invented by Dr. Fau is very useful, especially in depositing metal upon small plaster figures. It consists of an outer jar of glass porcelain, or wood, A, and a diaphragm of the same form, but of rather less diameter, D, constructed in the following manner. A sack, made of sail cloth, is half or three parts filled with a half liquid paste of clay, free from lime, into this sack is introduced a porous cell, as thin as possible; the combination produces a diaphragm which will resist the mixture of the solutions for a very long time. It is necessary to take care that the clay does not pass over the top of the porous cell. A broad ring of zinc, Z, surrounds the sack, at a distance of about half-an-inch, to which is soldered a thin strip of copper, a small platform of copper supports the object, and is connected with the zinc by a conducting wire and a binding screw, B. To put this apparatus in action, fill the porous cell with a saturated solution of sulphate of copper, and place it in the jar, which fill with salt and water till both the liquids are of the same height. Then unite the copper supporting the statuette, or other object to the zinc by the binding screw, and place them in the apparatus in such a way that the zinc surrounds the diaphragm in the saline solution, and the object is immersed in that of the sulphate of copper, which should

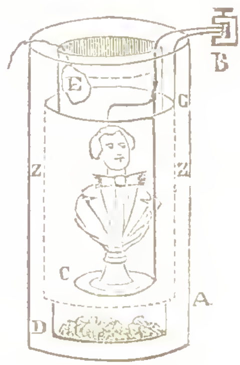


Fig. 20.

be kept saturated by placing a small bag filled with crystals of the salt, E, in the upper portion of the copper solution; the bag may be fastened to the exterior of the jar. The different parts should be so arranged, that the ring of zinc is at an equal distance from the diaphragm in all directions, and the surface of the zinc should bear some proportion to the extent of surface to be covered with copper. The size of the diaphragm must depend on that of the object, which should be in the centre of the ring of zinc, and not too distant from the porous cell. The following method may be adopted to mount the statuette upon the conductor: A disc of copper, A, having been selected corresponding to the pedestal of the statuette a wire is soldered to it, and the end of the wire is bent as in the figure. Another wire, B, ending in a point is attached to the former by small wire wound round it, the parts of these wires which come in contact, whether with each other or with the object, having been carefully cleaned and the statue, properly prepared, the latter is placed upon the disc and the second wire is bent down until the point just enters the plaster.—If the object be too large for a single conductor, a kind of stirrup may be made of the wire, and it may be supported by a glass rod laid across the top of the jar. If the point of the wire is carefully fixed in the plaster, the contact will be sufficient, but it is better to touch the point with a pencil dipped in a solution of nitrate silver. It is desirable to varnish the conductors and all the metallic parts, and if this is carefully attended to, the copper will be precipitated on the statuette with great rapidity.

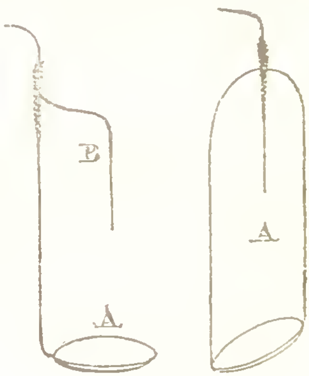


Fig. 21.

We are indebted for our account of some of the above very useful forms of apparatus and for that which follows to M. Valicourt's Appendix to the French translation of Mr. Smee's Work. Other important facts, of which we have made a liberal use, are stated in this useful little volume, a rare example of great value, and extreme cheapness combined.

A modification of the single-cell apparatus by M. Bean is worth notice. In a glass or earthen receiver, R, filled with sulphate of copper

is placed a circular porous tube P, within which is a tube of zinc, of somewhat less diameter. A sort of gallery of copper wire, G, which is soldered to a band fitting tight round the zinc extends over the porous jar. The porous jar being filled with dilute acid, the objects to be metallized are attached to different parts of the wire gallery, by which arrangement many may be done at the same time. The saturation of the copper solution may be maintained by a wooden funnel pierced with holes, filled with crystals to be dissolved, or by a linen bag enclosing the same crystals.

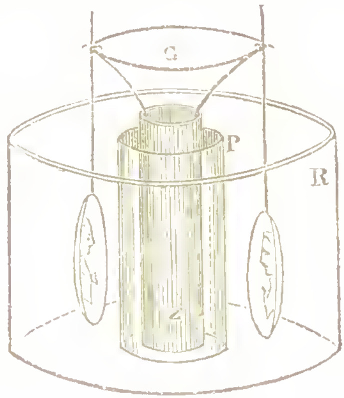


Fig 22.

Dr. Frankenstein has invented a method of gilding and plating metals by simple galvanic contact, which may be turned to account in the reduction of the metals. His principle is that the simple antagonism of the electricity produced by contact, that is the positive state of the object to be covered, and the negative state of the metal in solution to be precipitated, is sufficient to produce the required result. The plan of operating is as follows:—on a bar of wood placed across a vessel of glass or earthenware a band of zinc is fixed, the ends of which bent in the form of hooks descend into the metallic bath, a small way only to prevent the waste of metal which would be precipitated on the zinc, but always in contact with the object to be acted upon. If this is large it should be brought into contact with the zinc in three or four places, and the extremities of the zinc should be carefully cleaned. It is well even to change the points of contact occasionally. The solution must be kept saturated; and the bands of zinc should be moistened from time to time with a little acidulated water, and the oxide removed, which would otherwise impede the operation. We shall notice this method again when we come to speak of plating and gilding.

It would be impossible to include, within our narrow limits, a description of every form of single-cell apparatus which may be found at the opticians. Having noticed those most serviceable to the amateur, we proceed to explain the manner of using them.

MANNER OF USING THE SINGLE CELL APPARATUS.

Having selected the form of apparatus most convenient for the purpose required, place the zinc, always properly amalgamated, in the porous diaphragm containing the acid or saline solution intended to act on the metal. The former solution may contain about one part of sulphuric acid in nine parts of water. The latter should be saturated. The saline solution does not require the amalgamation of the zinc, and is only desirable when a very gentle current is required, or when iron is used as an element instead of zinc. The jar or trough is now to be filled with a solution of sulphate of copper, which must be saturated, or nearly so. It may be procured by adding the crystals, which are cheap and easily obtained, to boiling water, until the water will dissolve no more. The solution should be carefully filtered before using. It is not of very easy decomposition, but is rendered more so by the addition of about one-third of its bulk of diluted sulphuric acid—one part of the acid to eight of water. A dram of strong nitric acid is sometimes added to this solution, and greatly facilitates the passage of the galvanic current. The acidulated solution must be used with caution, and with a due regard to the nature of the object upon which the copper is to be deposited. A supply of the crystals is to be laid on a pierced shelf, attached to the apparatus, or suspended over the mould in a linen bag. By this means the strength of the solution is maintained; for as the heavier parts of the fluid fall towards the bottom, the crystals above are gradually dissolved. The mould, or other object to be covered with copper, must be carefully prepared according to the directions given in the former part of the work, and the wire or strip of metal attached to it firmly connected with the zinc by means of a binding screw; particular care being taken that the points of connection are made bright and clean, by passing a file, or piece of scouring paper, over them. The mould may now be introduced into the copper solution, very carefully and gradually, in order to avoid the bubbles of air which would otherwise form upon it and disfigure the copy. A deposit of copper will almost instantaneously appear at the point where the wire is joined to the mould; and this, if the mould is a good conductor, or well covered with a conducting substance, such as plumbago, will soon spread, and at length cover the whole surface. As soon as the deposition has decidedly

commenced it is desirable to withdraw the plate for an instant and to remove any bubbles that may have formed by blowing strongly upon it. If the conducting surface of the mould should be imperfect, there will be spots left, upon which the copper will not deposit; this may sometimes, though not always, be remedied by removing the mould from the solution, drying the surface where necessary by blotting paper, and then rubbing in with a brush as much black-lead as can be made to adhere. If one such attempt to give a complete conducting surface should fail, it may be repeated; but if finally unsuccessful, the mould must be replaced by another. The copper so irregularly deposited may however frequently be removed without injuring the mould, which may undergo a fresh preparation. The deposit of copper should present a beautiful bright pinky appearance, which a little practice will soon enable the operator to recognize. Various circumstances influence the kind of deposit which will be obtained. The laws which regulate the deposition of the medal, and the dispositions necessary to produce the most valuable deposit will be noticed presently, after we have spoken of some other arrangements of electro-metallurgic apparatus. The time necessary to form the deposit will depend upon many circumstances, the thickness required, the temperature at which the operation is carried on, the strength of the current employed, etc. A very little practice will enable the operator to determine when a sufficient quantity of metal has been deposited.

It will be necessary to remove the plate of zinc from the porous cell every twelve or twenty-four hours, and to well wash it in water. A little water must also be added to the acid solution in the porous cell, in order that the sulphate of zinc may be dissolved as rapidly as possible. These points must be carefully attended to.

BATTERY APPARATUS.

The Battery Apparatus, introduced by Professor Jacobi, is in many respects an improvement on the single cell. It consists of a single pair of Daniell's, Smee's, or other suitable battery, with the negative pole of which is connected a plate of the metal to be deposited, and with the positive pole the object to be covered. Both these are immersed in a solution of the metal required, contained in what is termed a decomposition cell. By this arrangement the solution is kept saturated, the metal plate or *anode* being dissolved in about the same proportion as the

metal is revived on the object or *cathode*. And by various modifications of the size and form of the anode, and its distance from the cathode, the nature, quantity, and rapidity of the deposit may be regulated, while the size and number of the objects which may be coated at one and the same time are almost unlimited. A single cell of either of the batteries which have been before described may be used in connection with the decomposition cell, and is amply sufficient for the purpose. The decomposition cell, or precipitating trough, as it is sometimes called, may be made of glass, stoneware, or wood, and of various sizes and shapes, one being figured in the margin. As it is oftentimes difficult to procure cells of the exact form or capacity required, it is well to remember that they may be constructed of wood, tin, or lead, provided the inside is carefully coated with a composition given in the Appendix, which will render the wood impermeable, or overcome the conducting power of the metal. In a case of emergency indeed, a box of pasteboard rendered impermeable by being saturated with boiled linseed oil, and prepared with the composition just referred to, will answer the purpose. A cell of plaster of Paris may be made impermeable by the same means.

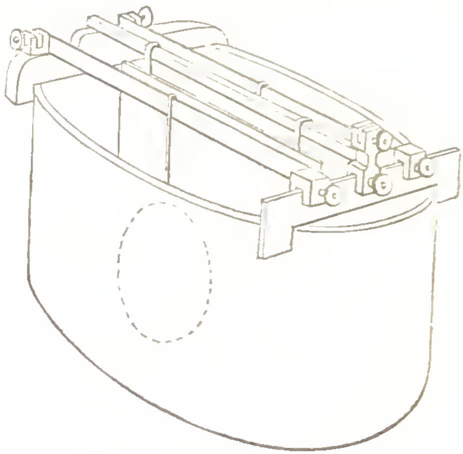
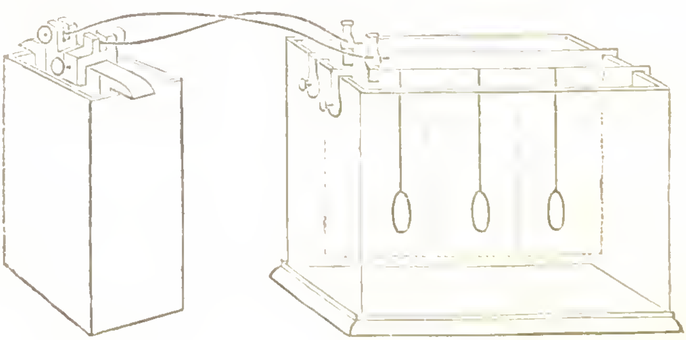


Fig. 23.



A Fig. 24. B

The arrangement of the battery apparatus will be seen by reference to the illustration. Fig. 24, A, is a cell of Smee's Battery, B the decomposition cell, filled with the saturated copper solution, a square rod of brass, to which is attached a plate of copper immersed in the solution, is connected by one of the wires with the silver plate of the battery, and another rod is connected with the zinc of the battery, to which the objects to be copied are

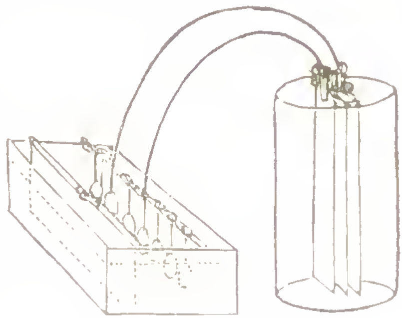


Fig. 25

suspended. [See also Fig. 25.] Five or six separate decomposition cells may be used in a series, and the copper deposited in each

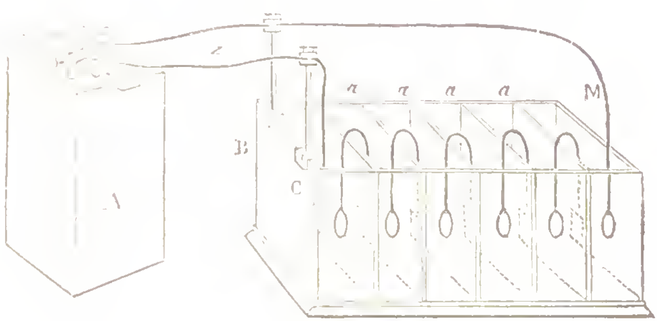


Fig. 26.

by the power derived from a single pair, or a decomposition trough may be divided into distinct cells as in Fig. 26. In this case a weaker solution must be used, and more acid added, to make it a better conductor. A piece of copper wire, *a*, bent, as in the figure, must pass from one cell to the other. To one end of this wire, the mould is to be attached, and to the other a piece of copper. The arrangement of the whole is therefore as follows:—In the cell nearest to the battery is placed a piece of copper connected with the silver of the battery, and the objects attached to the wire, in connection with the zinc in the further cell. The wires are now placed in such a manner, as that the mould at the end of one wire is directly opposite to the piece of coppe

at the end of another. By this arrangement a considerable saving is effected, as the quantity of copper deposited in each cell is equal to the quantity of zinc dissolved in the battery. Thus, if there be six cells, six ounces of copper will be obtained for every ounce of zinc.

In charging the apparatus, connect the plate of copper, C, in the cell nearest the battery, A, with the silver; place one end of a piece of copper wire in the same cell, and the other in that at the further end; now connect the mould with the zinc of the battery, and immerse it in the solution contained in the further cell, and in a short space of time it will be covered with copper. When this has taken place, remove the end of the piece of wire from the further cell to the next in order, and introduce one of the bent wires with the plate and mould at either end; when this also is covered with copper, again remove the wire, and proceed as before until all the cells are occupied. The trough of a Wollaston's battery is very useful for this purpose. A precipitating trough in which the object and the copper plate to be dissolved are placed horizontally, the object at bottom and the plate over it, is sometimes used. This arrangement is not quite so commodious as the others, but it has the great advantage of obviating the evil arising from the varying density of the solution, which is the cause of the stripes or lines which are often found on a metallic object when placed vertically in the trough. Now as the heavier parts of the solution always fall towards the bottom, a mould placed horizontally will receive an even and regular deposit. The management of the battery apparatus is attended with some difficulties, which, however, a little attention and practice will enable the amateur to overcome. The size of the copper plate must be determined by that of the object or objects to be copied. Surface for surface it may be a little larger than the object, and as thick as may be convenient. If it is desired to use only a portion of the surface the remainder may be coated by a varnish, which will protect it from the action of the fluid in which it is immersed. The plate undergoes dissolution, whilst the copper of the solution is released at the negative wire, and deposited on the object; and thus the saturation of the solution is kept up without a supply of crystals. In using the apparatus it is desirable in all cases to adopt the following order:—First, to put the battery in action, then to connect the silver of the battery with the copper plate, and place the latter in the solution; finally, after connecting the copper wire attached to the object to the zinc of the battery, carefully immerse the object in the solution, thereby completing the circuit.

Attention to these directions will prevent the metallic moulds from being acted upon by the solution. When moulds rendered conductible by plumbago are used, it will be found, as we have before stated, that the deposit will commence at the point of connection with the wire of the battery, and spread slowly and gradually from that point. The power of the battery being thus directed to a small portion of the surface, it is very probable that a very brittle metal will be thrown down, until, by the spread of the deposit, the relation between the power and the surface to be coated is more evenly balanced. This must be prevented in one or other of the following ways: either by the use of guiding wires, which are small wires twisted round the connecting wire, and touching the mould at various points, particularly where there are any hollows or depressions, or by using a wire, as the anode, instead of the copper-plate, until the mould is entirely covered, when the wire may be withdrawn and the plate replaced. The deposit should present the bright pinky appearance before alluded to; but there are many deviations from this standard, to which we must now devote a brief consideration. Metals are reduced in three different states; in black powder, in crystals, and in a flexible state, with the appearance noted above. All deposits take one or other of these forms, or intermediate states. Mr. Smee, who has devoted much attention to the examination of this branch of the subject, has laid down the following propositions as the laws by which the deposit is regulated:—

"Law 1. The metals are invariably thrown down as a black powder, when the current of electricity is so strong, in relation to the strength of the solution, that hydrogen is evolved from the negative plate of the decomposition cell.

"Law 2. Every metal is thrown down in a crystalline state, when there is no evolution of gas from the negative plate, or no tendency thereto." By being no tendency to the evolution of hydrogen, he means, that "the strength of the metallic solution is so great that either electricity of a much greater tension must pass, or the solution must be rendered of more easy decomposition before gas would be evolved."

"Law 3. Metals are reduced in the reguline" or flexible "state, when the quantity of electricity, in relation to the strength of the solution, is insufficient to cause the production of hydrogen on the negative plate in the decomposition trough, and yet the quantity of electricity very nearly suffices to induce that phenomenon."

A careful consideration of these laws will enable us so to modify the various relations as to produce exactly that kind of deposit which we may require. We shall defer the consideration of this subject, as far as it relates to other metals than copper, to our Second Part, offering here only a few observations which will enable the student to regulate the deposit of copper from the solution of its sulphate.

There are many circumstances causing variations in the deposit. These may arise from too great or too little power in the battery, with the various modifications which attach to that part of the apparatus, or from the varying strength and conducting property, temperature of the metallic solution, the relative sizes of the poles, and their distance from each other. It is desirable, however, to make the strength of the solution invariable, and then to regulate the quantity of electricity by arranging the conditions of the battery and trough accordingly. If after arranging the apparatus for use, connecting the mould, and immersing it in the metallic solution, it be found that a crystalline or sandy deposit takes place, when we wish to obtain one that is smooth and flexible, it will be well first to increase the distance between the object and the sheet of copper in the precipitating trough; if this does not succeed, we can either reduce the strength and quantity of the acidulated solution in the battery, or diminish the size of the copper-plate in the precipitating trough. If we desire, on the contrary, a crystalline deposit, we approximate the object and the copper in the trough, we increase the strength of the battery solution, or we enlarge the size of the copper-plate. The time occupied in the deposition of the metal by the battery apparatus is somewhat greater than by the single cell, but a very tolerable thickness of copper is attainable in about forty-eight hours. This, however, depends much on the temperature. In winter it is difficult to get any thing but a very slow deposit, in summer, on the contrary, it is obtained with considerable rapidity. In certain circumstances it may even be desirable to accelerate the process by keeping the metallic solution at a high temperature by artificial heat.

The action of the Battery in this apparatus will gradually become weaker, unless the plates are occasionally withdrawn and well-washed, and the acid solution kept at the same height by the timely addition of water. The metallic plate in the decomposition trough should be washed at the same time; the mould need not be removed from the solution.

When the object has obtained the desired thickness of copper, it

must be removed very carefully from the solution, and thoroughly wiped or dried with blotting paper, as one drop of the liquid getting between the mould and the deposit would stain the latter. The copper will generally grow or extend over the sides of the mould, and it may be necessary to remove this before it can be withdrawn; a half-round file will be useful for the purpose. When this has been done, the point of some sharp instrument, as a bradawl, may be introduced carefully into the mould, which may usually be lifted out without much trouble. Should it however adhere it may be slightly warmed, which will assist its withdrawal. The mould will generally be quite spoiled by this process. When it is made of fusible metal, or lead, and adheres tightly, it must be melted out. The removal being accomplished, the edges must be filed round till all excrescences are removed, and a neat smooth edge is produced.

GILDING, PLATING AND BRONZING.

The method of gilding and plating by the Electrotype process will be fully explained in the Second Part. With reference to medallions it may be mentioned here, however, that a single battery apparatus is used for the purpose, and that strong solutions of the auro or argento-cyanide will be found most convenient: the gold, or silver pole, must be of the size of the medal to be gilt or plated. The object must be thoroughly cleaned before immersion in the solution, and a very thin coating will be all that is necessary.

Medals and other objects to be bronzed must be carefully cleaned by rubbing them with rotten-stone, or fine emery and soft-soap moistened with water. A hard brush is best adapted for this purpose, provided it does not scratch the surface. If much oxidised, they may be dipped for a second or two in nitric acid, diluted in half its volume of water, and immediately rinsed in clean water, a little pearl-ash and water at boiling heat, or turpentine, will remove grease. This cleansing process, which must be used immediately before bronzing, may be completed by well rubbing with a soft plate-brush or leather.

Bronzing has the double advantage of preventing the oxidation of the surface which invariably follows the exposure of the newly deposited metal to the air, and of imparting a more chaste and beautiful colour. Receipts for bronzes are very numerous, we have selected a few

of the best that have been published. The simplest method, perhaps, is to heat the medal over the flame of a spirit lamp, until it is too hot to touch with the hand, then to brush a little plumbago over the surface until the desired tint is obtained. It is however uncertain, and the colour depends materially on the freshness of the object, and the care with which the surface has been cleaned. Medals taken from wax moulds require cleaning with pearlash or turpentine. Rouge slightly moistened with water, spread on the heated medal, and treated in the same way as the blacklead produces a fine bronze. The application may be repeated if the first attempt is not successful. Dr. Farr has recommended the use of a very weak solution of hydro-chlorate of ammonia, or of sulphate of potash, with which the specimen is to be moistened. M. Rockline applies a layer of rouge, slightly damped, and heats the medal to a red heat; the oxide of iron is removed by pouring a saturated solution of acetate of copper, quite boiling, over the surface, and then rubbing the medal dry with cotton.

French Bronze.—Take bloodstone five parts, blacklead eight parts; grind these substances together on a glass with a little spirit of wine until a paste almost solid is produced, which preserve for use. When about to bronze, soften the paste a little with spirit; lay it rather thickly upon the surface of the medal, and leave it for twenty-four hours. Then brush with a moderately hard brush till it presents a uniform and brilliant polish. By combining the two substances in various proportions, a lighter or deeper tint may be obtained.

Mr. Walker's Chemical Bronze.—Two ounces carbonate ammonia and one ounce acetate of copper, are to be boiled in half-a-pint of vinegar, until the latter is nearly evaporated. Into this pour a solution of 62 grains of muriate of ammonia, and 15½ grains of oxalic acid in half a pint of vinegar. Heat the mixture until it boils; when cold, strain and preserve for use. To apply it, clean the medal thoroughly and warm it; then brush the surface over with a camel's hair pencil dipped in the liquid for half a minute; immediately pour *boiling* water over it. Directly it is dry, rub its surface lightly with a soft cotton very slightly moistened with linseed oil; gentle friction with dry cotton will finish the operation. Should a green powder afterwards form on the surface, it may be removed by the moist and dry cotton.

BRONZE USED IN THE FRENCH MINT.—Take of verdigris twenty ounces; sal ammoniac nineteen ounces; a glass of strong vinegar. Pulverise together the verdigris and sal ammoniac. Take a quantity of this mixture about the size of an egg and make it into a paste with portion of the glass of vinegar. Put this paste into a copper saucepan (untinned), adding two quarts water. Boil it for twenty minutes and decant. When you wish to bronze, put into the saucepan a portion of the decanted liquor, and plunge the medals into it, supporting them on brackets of white wood or glass, to isolate them from each other and prevent their coming in contact with the saucepan. Boil them about a quarter of an hour.

CHINESE BRONZE.—This method of bronzing is pointed out by Capt. Pidding as one much employed by the Chinese. The article to be bronzed is first rubbed with ashes and vinegar, until the copper is quite clean and bright. It is then dried in the sun and entirely covered with the following composition :—Two parts (by weight) of verdigris, two of red lead, two of sal ammoniac, two of ducksbill, and five of alum, well powdered and mixed together, and moistened sufficiently to form a paste that can be spread on the articles. When the object is thus covered, it is heated over a fire, removed, and, when cold, washed. It is now covered a second time with the composition, heated and washed as before, and this process is repeated ten times. The objects so bronzed are very beautiful, and will bear exposure to the weather without injury.

To give an antique green to copper—Take white vinegar a pint; sal ammoniac half an ounce; salt half an ounce; liquid ammonia one ounce. Apply this composition with a brush, repeating the operation two or three times.

MOUNTING ELECTRO-MEDALLIONS.

The directions we have given for copying medals and coins would hardly be complete, without a few words on the best way of mounting them when finished. This may be done by placing the obverse and reverse side by side, or by filing the back of each flat, and uniting them together by glue. They may be made to resemble the originals, still more closely by the following method :—make a ring in copper, of the same diameter as the medal to be imitated, and of the thickness of the

same medal laid flat. This ring being carefully turned and polished, solder the two surfaces of the medallion upon it. When the whole is bronzed, a perfect fac-simile of the original is obtained. A very perfect rim is produced by a thin piece of metal wound round the edge of the mould, and projecting slightly beyond the surface, before it is introduced into the metallic solution. Medallions should be arranged in trays lined with paper of a suitable color; thus, gold on a green ground, lilac on light blue, and bronze on a pale yellow.

Having given the reader such plain directions as will, we trust enable him, with a little care and study, to master every part of the Electrotype process, as far as relates to the production of works in copper, we shall devote a page or two to the consideration of two or three applications of this art, of a somewhat different character to those which we have yet noticed, and such as require more particular directions for their successful accomplishment. And first, we shall refer to the method—

OF COPYING DAGUERREOTYPES.

These exquisitely beautiful and delicate pictures may be transferred to copper in all their beauty, and with even additional softness and richness of tone. The method of procedure is very simple. The plate is connected with the battery by a wire, which, as it cannot well be soldered without injury to the picture, must be bent into such a form as will support it in the solution, and ensure connection. The back of the plate may be slightly greased or varnished. to prevent the copper from depositing. A piece of copper, of about the size of the plate to be covered, must be used to the anode. Connect this with the silver of the battery, and immerse it in the metallic solution in the decomposition cell. Well stir this solution, and then having connected the daguerreotype plate with the zinc, immerse it steadily but quickly in the solution. The metal will be deposited instantly over the whole surface. The deposit need not be very thick, and the process in moderately warm weather will not occupy more than twenty-four hours. When withdrawn from the solution the plate must be carefully wiped and dried with blotting paper; the application of a sharp file to the edges all round will soon remove the surplus metal; the daguerreotype and

the copy should separate easily, but if any adhesion occurs, it should be gently warmed, which will facilitate the removal. It will be sometimes found that the copy is covered with stripes; this arises from the different states of the metallic solution, arising from the gravitation of the particles of metal in solution. To avoid this, care should be taken to stir the solution well before introducing the plate, or an apparatus may be used in which the plate can be placed horizontally at the bottom of the trough. The copy should be immediately placed under glass to prevent its tarnishing. It is said to improve by exposure to the rays of the sun.

MULTIPLYING ENGRAVED PLATES.

This branch of the Electrotype has been largely applied of late; and to it we are indebted for the multiplication of beautiful engravings which could not, but for this process, be published at the moderate price which now puts them within the reach of all classes. For periodical or serial publications, having a large circulation, it is invaluable.

An impression is taken from the original plate by one of the methods pointed out in the former part of this work, or the plate itself may be placed in the solution, and a relievo obtained which will serve as a mould, from which as many copies as may be required can be taken. In the latter case a flat band is soldered on to the back of the plate, which will serve to connect it with the battery. There is one circumstance connected with the soldering which must be borne in mind whenever metallic plates are to be placed in the solution and a metal to be deposited on them. The two plates are alone prevented from adhering together by a film of air which protects the original. Now, the heat applied in soldering will probably disperse this film, which will not be restored again until after some hours. The plate which has been soldered should be exposed to the cool air for from twenty-four to thirty-six hours before it is placed in the solution.

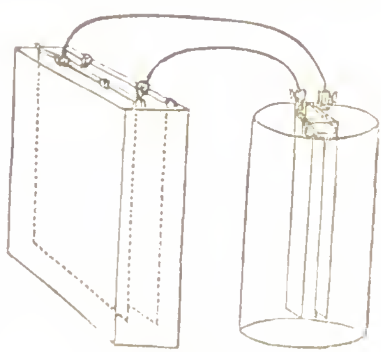


Fig. 27.

The same remark applies to daguerreotype plates; the heat used in drying them off will sometimes cause them to adhere in places if the film of air has not been restored in cooling. All danger of adhesion may be prevented, as far as the engraved plates are concerned, by warming the plate and rubbing a little beeswax over the surface; while the plate is warm the wax may be rubbed off with soft cotton until quite clean. Those parts of the plate which are not to receive the deposit must, of course, be protected by grease or varnish. The apparatus figured on the other side is a useful one for this process.

ETCHING BY GALVANISM.

In this operation an etching ground is prepared in the ordinary way, the plate having been previously connected with a stout ribbon or wire by soldering. The design is traced through the ground with a finely-pointed etching tool; and the back and edges of the plate, as also the wire, covered with varnish, to protect them from being acted upon. It is then placed in the decomposition cell, filled with a solution of sulphate copper, and connected with the silver of the battery, a piece of copper of about the same size as the plate being used as a negative pole. A portion of the copper of the solution will immediately be deposited at the negative pole, and the copper of the etching plate proportionably dissolved to supply the deficiency. The rapidity of the action may be increased by bringing the two poles nearer together, or *vice versa*. After the plate has been acted upon for a few minutes, it may be withdrawn, and the finer parts stopped out; it is then replaced, and after the lapse of a few minutes, removed again, and the half tints stopped out, and so on,—this part of the proceeding being regulated by the judgment of the operator and repeated as often as may be necessary. When finished, the ground is removed by the application of heat, and the plate printed from in the usual method.

Daguerreotype Plates.—An arrangement somewhat similar to the above may be employed for etching the beautiful pictures formed on silver plates by the Daguerreotype process; but it is found to be difficult if not impossible to print distinctly from these plates, the minute lines being either removed by the process of etching or choked up by the ink used by the printer. Hydrochloric acid is employed as the solvent, and a plate of platinized silver as the negative pole. The

two plates should be placed in a frame, about the fifth of an inch apart, the back and edges of the daguerreotype plate being, of course, varnished. A single pair of plates, of a Smee's battery, as near as possible the size of the former, may be used, and connection made by wires touching the edges of the two plates in the decomposition cell. This process will be described more at large in the Second Part.

GLYPHOGRAPHY.

A patent was taken out, in 1842, by Mr. Edward Palmer, for a method of engraving original drawings, to which the above name is applied. A plate of copper, as used for engraving, being first procured, is blackened with the sulphuret of potassium. A composition of burgundy pitch, white wax, resin, spermaceti, and sulphate of lead, melted together, is spread over the blackened plate, previously warmed, to about the thirtieth of an inch in thickness. The artist uses simple tools, which will cut out the white composition completely without burrs; several kinds of which are described in the patent. The black lines which appear on the plate when the drawing is finished, are just those which will appear on the paper when the design is printed. From the plate thus prepared, casts are taken, after a certain treatment depending upon the description of cast required. In one case the electro-glyphographic cast, the high lights are built up with some non-conducting substance, that they may not print, the plate is placed in a solution of copper, and a copy taken by the aid of the battery in the mode already described—from this copy, when properly mounted, the impressions are taken. In the other case, the stereo-glyphographic cast, a cast is taken in plaster, when the high lights are cut out, and any lines inserted which were omitted in the first drawing. The cast is then oiled, and another taken from it. From this last a stereotype plate is obtained, which is ready for the printer; but both the processes are now superseded by another branch of the same patent, namely:—"The obtaining Surface Blocks from already *Engraved* or *Etched* Copper Plates." Maps or writing are *engraved* forwards, portraits landscapes, figures, etc., are *etched*, but finished in the etching, and full effect given to the design, when it is bitten in with nitrous acid, and by the aid of the galvanic battery a surface block is obtained from it; the blocks have these advantages, they contain all the freedom and

taste of the artist's etching, very large numbers can be printed from them without deteriorating, and they can be made of any size in one block. *

Another patented process of Mr. Palmer's is the Electrotint, in which a painting is made upon a copper-plate with some substance insolnable in the solution of sulphate of copper; from this a reverse is made by the galvanic process, and handed over to be printed from.

The battery (Smee's) must, of course, bear a reasonable proportion to the size of the plate to be copied, and in some cases three or four cells may be employed with advantage. It must be charged with dilute sulphuric acid, one part of acid to about sixteen of water. The precipitating trough may be horizontal, as in fig. 19, or vertical as in fig. 27. If one battery is used, a saturated solution of sulphate of copper, diluted with a third of sulphuric acid, may be poured into the trough; if more than one, a saturated solution without acid may be used. In all cases it is well to commence with a neutral solution, and when the plate is covered with a layer of copper, to add the acid. The battery and trough being thus prepared, a piece of copper of the same dimensions as the plate is attached to the silver of the battery, and immersed in the solution; then the plate itself is connected with the zinc, and carefully placed opposite and parallel to the copper pole in the trough. They may be separated or brought nearer together according to the texture of the copper deposited. The temperature of the copper solution may be kept moderately high, in which case the deposit will be better and more rapid. The battery must be examined occasionally, and supplied with acid and water as may be necessary. The copper should also be taken out and washed, and the solution well stirred. When the deposit is of a sufficient thickness, the plate may be carefully removed, dried, and the plate and copy separated by filing off any copper which may overlap the edges; the plates should separate without any difficulty. If the back of the plate is rough, it will require filing; and if too thin, a plate of tin or iron may be soldered to the back.

Copper Plates for engraving may, by the same method, be made from other copper plates; and though more expensive than copper plates made in the usual way, they are said to be very superior and much more easily engraved.

* A beautiful specimen of Glyphography forms the Frontispiece to this Manual.

WOOD CUTS.

Nothing has contributed more extensively to the illustration and embellishment of our literature than the perfection to which this branch of art has been carried within the last few years. While a very large number of impressions can be taken from wood blocks, without much injury to the work, a fac-simile in metal is frequently required, to enable a greater number of copies to be printed within a short time, or to preserve the original cuts from all chance of injury. These copies are taken either by the ordinary process of stereotype, or by the agency of the galvanic battery; in the latter case a reverse is made from the cut in clichèe, metal, plaster, or wax, which is prepared and treated in the same way as any other mould. The Electrotype so obtained will require backing up. It is found, we believe, that better impressions are produced from the copper than from the original blocks.

ENGRAVED DRAWING.

Professor Kobell, of Munich, has succeeded in reproducing paintings and drawings, made on silver or copper-plates, by the following process. A plate of copper, or, what is still better, of copper, plated with silver, being highly polished, a drawing or painting is made upon it by means of rouge moistened with a solution of wax and a little gumlac in essence of turpentine. The design should be light and delicate: but when very intense shadows are introduced, these should be charged with a coat of oil color, and covered with finely-powdered black lead, which is all the preparation the plate requires. This plate is placed upon another copper-plate, to which a band of copper is attached, and isolated by waxing the sides. A plate of zinc is placed in a kind of tambourine, a cylinder of glass over the under part of which a piece of bladder is stretched, supported on legs. A strip of lead is soldered to the zinc. The cylinder is placed in an earthen or glass vessel, nearly filled with a mixture of one part by volume of sulphate of copper in water, and one part dissolved in a solution of glauber salt. Into the cylinder is poured a small quantity of water, to which has been added a few drops of sulphuric acid. The plates of copper and the zinc being properly placed, the first in the solution underneath

the cylinder, and the zinc in the cylinder, the two bands connected with them may be united by a binding screw, and the action will at once commence. The zinc should not act directly upon the parchment, but two or three pieces of glass tubing should be interposed between them. The copper will be deposited at first upon the clear portions of the painted plate; but after a little while small protuberances of copper will appear on the painted parts, which will grow and spread until at length every part is covered completely. At the end of three or four days for a small plate, or of six or eight for a plate of the size of a quarto volume, the coat of copper is thick enough to remove. Care must be taken that the deposit is not a brittle one, which will be the case when the bladder does not entirely prevent the passage of the acidulated solutions when the copper solution is not kept saturated, or when the zinc is not kept cleaned. The cylinder and zinc, and the connecting wires, should be washed at least every twenty-four hours, and a fresh acidulated solution added. When the plate is sufficiently thick, the surface is levelled with a fine flat file; the plate being placed between two other plates of a smaller size, is held fast by a wire, and then the sides are filed down, until the deposit can be separated from the drawing by the aid of a small ivory paper-knife introduced at the corners and going along each side. The galvanic plate is cleaned by wiping it over with a linen rag dipped in ether, and when polished with a leather and whitening is fitted for the press. A copper-plate printing press is used for this purpose: 5000 impressions may be taken from the plate. A greater number might be obtained by making several copies of this galvanic plate, on which any necessary corrections may be made. To prevent the adherence of these copper-plates, it is desirable to cover them with another coating of silver by the galvanic process. The apparatus should be set in action sometime before the copper-plate to be copied is introduced.

APPENDIX.

Cement for rendering Wooden Vessels Waterproof.—Melt together beeswax one pound, and rosin five pounds, add one pound red ochre, and two table-spoonsful of plaster of Paris.

Varnishes.—A solution of sealing-wax in spirits of wine, applied with a pencil to those parts which we wish to isolate, will entirely prevent the deposition of metal upon them. A little melted wax or tallow will answer the same end. It must not be forgotten that resinous substances will not resist the action of the cyanides, when solutions of these salts are used it is desirable to replace the wax by asphaltum dissolved in turpentine. Mr. Gandier has recommended a varnish composed of caoutchouc, softened in oil of turpentine, and then dissolved in rectified ether.

Bronze Powders.

We subjoin two or three receipts by which these powders may be prepared. Precipitate the copper from a boiling solution of its sulphate by adding distilled zinc; then separate the copper from the zinc by the action of dilute sulphuric acid; slowly dry the powder thus obtained.

Silver Powder.—This is obtained by boiling chloride of silver recently prepared, with water acidulated with sulphuric acid and very pure zinc.

These metallic powders are readily applied to wax, stearine, or prepared plaster moulds, by dusting them on the mould, and then rubbing them well and evenly over the surface with a soft plate brush.

FLEXIBLE MOULDS.

Dr. Leeson has patented a method of moulding objects in high relief, of which the following is a summary. The object is brushed over with a solution of glue, about the consistence of treacle four or five times. A circle of tin or pasteboard is then arranged around the object, and at such a distance as will allow a quantity of the solution to be poured in, so as to strengthen it. A solution of caoutchouc and other gums or resinous substances may be added to the glue, or a leathery consistence may be given it by a solution of tannin. When quite solid it may be removed from the object by gently stretching it, or if necessary to be cut, it can be joined again with great accuracy. If an object is to be moulded to which the glue will adhere, it must be just moistened with a little oil. From these moulds casts in wax can be taken, which, when perfectly hard, in twelve or fourteen hours, may be withdrawn from the mould, and after preparation covered with metal in the ordinary way.

Mr. T. B. Jordan has pointed out the following method of moulding objects which are much underent; he particularly recommends it for very delicate specimens, such as insects, fossils, etc. He makes use of a composition which approximates closely to that of which the inking rollers used by printers are manufactured. This, we believe, consists of equal parts of glue and treacle melted together in a water-bath. This composition preserves a considerable degree of elasticity when cold, and can be removed without injuring the most delicate parts of the model. It is applied hot, and should be left twenty-four hours to dry before removal. It must, however, be protected by a solid varnish from the influence of the metallic solution, and will only serve for one copy. The copies obtained by this method can be variously tinted by rubbing them over with the double cyanide of silver and potassium.

Smelting Copper.—A most valuable improvement in this process has been patented during the past year. It is we believe the discovery of Mr. Napier. By it the same effect is produced in two days, which required three weeks under the old system. The saving in fuel is enormous; and the smelters in Swansea alone, estimate this annual saving at no less than five hundred thousand pounds.